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NORAD Weekly Intelligence Review

Issue No. 14/64, 3 April 1964

The WIR in Brief

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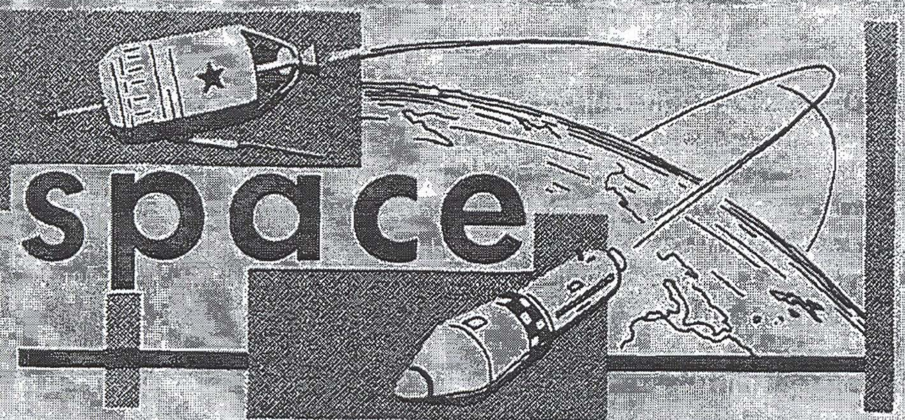

significant
intelligence
on space
developments
and trends

Missions of 'Electrons 1 & 2' Described in Detail in 'Pravda'

A NORAD translation of an article published in the 15 March issue of Pravda follows.

THE 'ELECTRON' SPACE SYSTEM

New Successes of Soviet Science in the Exploration of Space

More than a month has passed since the scientific stations Electron-1 and Electron-2 were launched into near-Earth space. The simultaneous study of radiation belts of the Earth was the basic task of these stations. Today we publish an article by scientists about the importance and the construction of the Electron space system.

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1. The Radiation Belts of the Earth. Soviet science and technology opened the road to the cosmos. The flights of the sputniks have provided much useful information about cosmic space, and have led to the development of new, hitherto unknown phenomena of nature -- the Earth's radiation belts.

The ultimate exploration of cosmic space for man's practical purposes, such as the realization of superlong-range radio communications and reliable, timely weather forecasting and the creation of space laboratories, requires a detailed study of the characteristics of space. The launch of communications satellites equipped with complex apparatus for relaying television signals and meteorological satellites with automatic instrumentation for the conduct

of meterological research requires that instrumentation operate over lengthy periods under space-flight conditions.

On 30 January 1964 the Soviet Union successfully launched a space system consisting of two scientific stations -- Electron 1 and Electron 2 -- injected into essentially different orbits, using a single powerful carrier rocket. The advent of this system opened up new possibilities for the study of the near-Earth space environment, of special significance to the growth of astrophysics. Electrons 1 and 2 are being used to conduct a wide variety of measurements necessary for a deeper understanding of the physical processes occurring in various regions of the near-Earth space environment.

One of the fundamental problems of sputniks Electrons 1 and 2 is the study of the inner and outer radiation belts of the Earth. Extremely large streams of charged particles in the radiation belts bombard every object which enters these belts. The energies of these particles are so great that they can penetrate space ships.

Exposure to this radiation is not only dangerous to the health of cosmonauts making lengthy flights in the radiation belts but also causes changes in the characteristics of various materials used in space objects. It has been established that silicon solar batteries used on satellites and space rockets, are less able, after exposure to particles of these radiation belts, to generate electrical energy. When exposed to very strong radiation, solar batteries can be put out of order, as happened to several American satellites after a high-altitude nuclear explosion by the USA on 9 July 1962 sharply raised the intensity of emanations in the radiation belts.

It is also known that certain transparent materials lose their transparency when exposed to radiation -- they become clouded, which is especially undesirable for optical systems. Many organic materials applied in thin films to the surfaces of various objects -- for example, for the clarification of optical lenses -- are destroyed by exposure to radiation.

The study of the behavior of various materials in space is the field of a newly born field of science -- space material technology.

Before the reliability of some material or other in space flight can be determined, the radiation dosage which a given sample of it will receive must be known. In order to forecast the radiation dosage, scientists must know not only the condition of the radiation belts today but they must know how to forecast their condition tomorrow. For this it is necessary to know the laws governing the radiation belts, to understand their origin and how they are sustained.

A satisfactory explanation has been given of the nature of the internal radiation belt discovered by American scientists with the satellite Explorer I. When cosmic radiation destroys nuclei of atoms of the Earth's atmosphere, neutrons fly off in all directions and some of them leave the atmosphere. The lifetime of neutrons is more than 12 minutes. When a neutron disintegrates, charged particles -- a proton and an electron -- are produced. If a neutron disintegrates

close to the Earth, then the proton and electron are seized by the Earth's magnetic field and begin to move in spiral trajectories, traveling from the northern hemisphere to the southern and back again along magnetic lines of force. These particles complete hundreds of millions of trips from one hemisphere to the other before their death. Each such trip is shortened by some seconds. Thus it is that the Earth's magnetic field is a trap for charged particles. Many particles can accumulate in this trap, since at high altitudes the density of matter is extremely small and particles moving about there lose their energy very slowly. This hypothesis explains well the experimental data about the composition and energy spectrum of the particles in the inner radiation belt. By comparing theory with experiment it is possible to derive information about the density of the atmosphere at altitudes of more than 1,000 kilometers.

A somewhat different picture is observed in the outer radiation belt discovered by Soviet scientists with the flight of Sputnik 3. It can be shown that the mechanism of the inner belt does not explain the existence of the outer belt. The outer radiation belt is still a riddle. Apparently, close to the Earth, at distances of thousands and tens of thousands of kilometers, some peculiar "cosmic accelerator" is at work. On the basis of data obtained by satellites we know how particles are in principle dispersed in this "accelerator." However, we do not know how this "accelerator" was "built."

When the Earth passes through a stream of particles issuing from the Sun, magnetic storms and polar aurora are observed. At the same time the strongest changes in the outer radiation belt are produced. This means that the "near-Earth space accelerator" is at work.

This is why, to solve the riddle of near-Earth space, various physical phenomena must be studied simultaneously. This requires the building of space systems consisting of a series of satellites which take measurements in various regions of the radiation belts at the same time. The launch of Electrons 1 and 2 is the first step in this direction.

Clarification of the nature of the "near-Earth cosmic accelerator" will aid in solving scientific problems of the greatest importance. It is already known that "cosmic accelerators" of incomparably greater magnitude exist. One is at work during so-called solar flares, which are thousands of times stronger than the "near-Earth accelerator." This solar accelerator generates particles with energies of up to 10 million electron volts. Situated in the depth of our Galaxy is an accelerator a million times as powerful, creating particles with energies of up to a million billion electron volts. Finally, beyond the limits of our Galaxy lie "accelerators" of still greater energies.

In order to understand the series of absorbing problems involved in creating the particles of high energies which make up cosmic rays, near-Earth space which is more accessible to us must first be studied.

7. The Orbits of Satellites Electron 1 and Electron 2. The choice of orbits of the space stations Electrons 1 and 2 was based on the need for studying simultaneously the upper layers of the atmosphere, the radiation belts of the Earth, and near-Earth space.

A number of other factors also were considered -- conditions for radio communications during transmissions from the satellites to ground stations, the orbital life expectancy of the stations, and the illumination of the stations by the Sun.

After considering a number of possible parameters for the Electron space systems, two orbits of great eccentricity were chosen. Such orbits enable scientific study at all the interesting altitude bands -- from the upper layers of the atmosphere out into space and beyond the limits of the radiation belts.

The first orbit lies in the most interesting regions of the inner radiation belt, partially intersecting the outer belt and intruding into the region of irregularities in the magnetic field, in which the unstable streams of particles which cause polar auroras are formed. The second orbit partially passes into the inner belt and the more interesting regions of the outer belt, entering the region beyond where there are nonstationary streams of electrons of low energy. This is known as the outermost belt of charged particles.

The apogee of the first orbit was to be 7,000 kilometers, which closely corresponds to the outer limit of the inner radiation belt, and the apogee for the second orbit was to lie within the limits 65,000-70,000 kilometers. The perigee of both orbits was to be in the 400-460 kilometer region.

It is essential that the focal axes of the orbits of the space stations (that is, the lines uniting perigees with apogees) extend in different directions. For the lower orbit, this axis was favorably oriented with respect to the inner radiation belt.

The focal axis of the plane of the higher orbit was oriented so as to get the most varied altitudes at uniform geographic latitudes in flight during ascending and descending turns of the orbit, which is important for scientific measurements needed in studying the outer radiation belt. The inclination to the Equator of both orbits was about 61 degrees. The magnitude of inclination strongly influences changes in orbital parameters caused by attraction of the Moon and Sun and by the flattening of the Earth. In the selected inclination, the perigees in due course will shift to the north and, what is especially important, the orbit of the station Electron 1 will in the course of a year pass through all thicknesses of the inner radiation belt.

A diagram of the orbits of the Electron space system is shown in Illustration No. 1 (page 31). Locating the perigees of the orbits in the northern hemisphere provides the most favorable conditions for conducting communications sessions between the space stations and ground receiving stations.

At the same time, the volume of information is at a maximum near perigee, since measurements connected with study of the upper atmosphere are made here along with study of the radiation belts.

It is known that Earth satellites moving in low orbits have a limited life expectancy, because of the braking effect of upper layers of the atmosphere. As the altitude of the orbit increases, the life expectancy of the satellite also increases, since the braking effect of the atmosphere is diminished. At the perigees of the Electron satellites drag is negligible. However, when apogee is on the order of tens of thousands of kilometers, new factors begin to influence noticeably the movements of the satellite -- the attraction of the Sun and Moon. Computations show that under an unfavorable combination of these forces, the orbital period of a vehicle having an apogee of 65,000-70,000 kilometers can be several days.

In this connection, a detailed study was made of the motion of satellites having orbits of high apogee and definite moments of launch, and Electron 2 should stay for a long time in the highly elongated orbit selected for it.

The most expedient way to create a space system having the required high-altitude orbits is the simultaneous injection of two space stations by one carrier rocket.

Possession by the Soviet Union of powerful space rockets permitted the solution of the problem in just this fashion. However, the practicality of injecting two satellites into essentially different orbits by means of a single carrier rocket poses significant technical difficulties. To inject the two Electron stations into the programed orbits, the first one had to be separated during the active portion of the flight, while the last stage of the rocket was still working. Electron 1 had to be separated in such a way that none of the resulting forces would influence the guidance system of the last stage and the precision of injection of Electron 2. When Electron 1 separated it also had to fall outside the zone of influence of the efflux of the engine of the last stage.

Both of these difficulties were overcome by means of a special reaction system which separated Electron 1 from the last stage of the carrier rocket at a strictly programed speed. Separation occurred practically without any interfering influence on the final speed of the last stage. At the same time, Electron 1 was so constructed that at the moment of separation the station would be most compact and would not have large projecting parts.

3. Construction of the Satellites and their Apparatus. Electrons 1 and 2 are automatic satellite stations developed for a complex study of near-Earth space.

Illustrations Nos. 2 and 3 (see page 34) show exterior views of both stations.

On the outside of the stations solar batteries, antenna systems, part of the instruments for scientific research, and solar orientation sensors are attached. Venetian blinds for heat regulation are mounted about the

cylindrical portion. Folding antennas and panels of solar batteries on Electron 1 open after separation of the station from the carrier rocket, on command from a time-programed device. This is done to facilitate separation of the station during the active part of the flight. On Electron 2 the panels of solar batteries are attached rigidly.

In consonance with the wide program of study of near-Earth space, various scientific devices were mounted on the Electrons to carry out measurements at many points of their orbits. The results are inscribed on memory devices aboard the stations. Scientific information and data about the work of the on-board systems are accumulated for one or several orbits, depending on how the memory devices are programed.

During communications sessions, stored data are transmitted along with real-time telemetry of a great number of parameters registered by the sensors, and data about the state of all the station's on-board systems. Operation of on-board devices is controlled by two methods -- automatically, and on command from special ground stations.

The attitudes of the Electrons in space are determined by means of solar orientation sensors, the indications of which are registered in the memory devices along with the measurements of the scientific devices.

Control of the Electron systems in flight -- the measurement of orbital parameters, the reception and recording of telemetric and scientific information, issuance of commands to switch on or off on-board apparatus is accomplished by a command-surveillance complex on the ground.

Communications sessions have confirmed that the Electron space system is reliably controlled by command from the Earth.

Now for the fundamental problems which must be solved by the flights of Electrons 1 and 2. As was said above, the basic task of the Electron space system is study of the inner and outer radiation belts of the Earth and related physical phenomena. For these purposes identical apparatus for recording electrons and protons of various energies were installed on both vehicles. These measurements are to determine the composition of emanations in the radiation belts simultaneously in two points of near-Earth space.

Electron 1 completes its flight around the Earth at a comparatively low altitude (less than 7,000 kilometers). It is used to study the inner radiation belt of the Earth and the near-Earth "spurs" of the outer radiation belt. Electron 2 at the same time cuts through the outer radiation belt and goes beyond it into interplanetary space, where there can be no particles of the radiation belts and where the basic form of emanation is cosmic radiation.

The use of identical apparatus on both satellites enables the drawing of a map of the spatial distribution of radiation belts and a link up of these measurements carried out by the different satellites at various distances

from the Earth. Some of the apparatus is installed inside the hermetic container. These instruments register particles of fairly high energy -- electrons with energies of more than 2 million electron volts, protons with energies of more than 30 million electron volts, and photons with energies of more than 50 thousand electron volts.

Particles of lesser energy cannot penetrate the hermetic container. Instruments have been installed on the exterior surface to register such particles. Radiation detectors are enclosed by the thinnest of sheets of materials. Their thickness is on the order of a few thousandths of a millimeter. Electrons with energies of more than 30 kiloelectron volts and protons with energies of more than a million electron volts penetrate these detectors.

For registering particles of still lower energies, a so-called spherical analyzer is used on Electron 2. There is no obstruction to the entrance of particles to this analyzer. Particles deflected in the electrostatic field are moved in circles. In flight an electrical tension applied to the spherical analyzer is automatically switched on. It detects protons and electrons of various energies, beginning with 100 electron volts.

Particles of low energies are measured also by a charged-particle "trap," similar to that which Soviet space rockets used to discover the ionized "geocorona" of the Earth and the outermost belt of charged particles which lies beyond the outer radiation belt and consists of electrons of comparatively low energies. Numerous measurements in the "geocorona" and in the outermost belt by detectors of low-energy particles will increase significantly the volume of information about these regions of near-Earth space.

Aboard Electron 1 is a radio beacon which transmits coherent radiowaves. Observation of these radiowaves by stations deployed on the ground make it possible to trace the propagation of radiowaves and to define the concentration of electrons at high altitudes.

On Electron 1, low-energy particles are registered by special counters in combination with an accelerator tube. To protect the cathode of the photomultiplier from light, the crystal counter must be covered by some kind of opaque material. No matter how thin the foil that covers the crystal, it still prevents electrons with energies of less than 10 kiloelectron volts from falling on the crystal. In front of the crystal is the accelerator tube which raises the energy of slow electrons to 10 kiloelectronvolts. In this way an instrument on Electron 1 can register electrons of the weakest energy (about 100 electron volts) up to several tens of thousands of electron volts. This data supplements that received by the various other instruments referred to above which are installed on the satellite. In this way, a wide assortment of instruments permits detailed study of the composition of the radiation, and a determination of the nature and energy spectrum of the particles which make up the radiation belts.

The motion of the particles of the radiation belts is determined by the magnetic field of the Earth. Therefore, information about the radiation belts supplements data about the magnetic fields. Also, the motion of particles in the radiation belts leads to a rise in electrical current which in its turn creates an added magnetic field. For recording magnetic fields far removed from the Earth, two magnetometers were installed on Electron 2 to measure the magnitude and direction of the tension of the magnetic field. One magnetometer is less sensitive, but it can measure adequately the magnetic field of the Earth. The other is to register weak magnetic fields found in the outer radiation belt and even at great distances beyond its limits.

The concentration of charged particles of various energies in the radiation belts and the magnitude of the magnetic fields created by them are intimately interrelated. Simultaneous measurement of various particles and of magnetic fields gives very important information about the Earth's radiation belts.

It is quite obvious that research concerning the composition of the upper atmosphere of the Earth is of great significance. In this article we would like to emphasize the possible connection between the radiation belts of the Earth and the composition of the upper atmosphere. In journeying from the northern hemisphere to the southern, particles of the radiation belts sometimes end their lives below these belts. Influenced by a number of factors, many of which have not been discovered, particles of the radiation belts are "poured" out of them and bombard the upper layers of the atmosphere. These belts thus affect the Earth's atmosphere. On the other hand, it is possible that in the upper layers of the atmosphere certain particles, after acceleration and exit from the limits of the atmosphere, become part of the radiation belts. Radio-frequency mass spectrometers have been installed on both Electrons to determine the chemical composition of the upper layers of the atmosphere.

Apart from the elementary particles (electrons and protons) surrounding the Earth, it is possible that so-called micrometeors -- of extraordinarily small size -- also describe orbits around the Earth. Thus experiments carried out by previous Soviet and US satellites established the fact that there are more micrometeorites near the Earth than in interplanetary space. This, apparently, results from the fact that micrometeorites approaching the Earth from interplanetary space accumulate as they spend a lengthy time orbiting the Earth. A micrometeorite detector has been installed on Electron 1 to register the number of hits during the journey of the satellite vehicle.

Also installed on Electron 1 is an instrument which registers X-rays from the Sun. Intensive X-radiation originates during powerful eruptions on the Sun, the so-called "flares." Recording these X-rays makes it possible to identify solar activity and to examine the connection of these phenomena with states of the radiation belts.

The creation of automatic laboratories flying far from the Earth also makes it possible to study radiation arriving from the depths of cosmic space.

A great part of cosmic rays is born beyond the limits of our solar system. The atmosphere and magnetic fields of the Earth pose substantial obstacles in the paths of these rays toward our planet. Electron 2 recedes far from the Earth, beyond the limits of its magnetic field. Therefore, devices for registering cosmic rays were installed on this satellite. Several of these instruments measure not only general intensity of cosmic rays but also determine their chemical composition, that is, identify the nuclei of atoms encountered and the quantities in which they are found in cosmic radiation.

Even in deep antiquity people observed celestial bodies extremely remote from us. This was possible thanks to the fact that the eyes of man are able to see stars situated far from us. The potential of modern astronomers rose powerfully when it became possible to observe invisible as well as visible rays arriving from the cosmos -- radiowaves. Thus was born a new science -- radioastronomy.

As is known, the Earth is surrounded by an ionosphere which reflects short, medium, and long radiowaves. Thanks to this characteristic of the ionosphere, it is easy to communicate between radio stations on various continents of the Earth. But owing to this same cause, those radiowaves which are long -- more than 100-150 meters -- cannot reach us through the ionosphere from the cosmos. When they reach the ionosphere they are reflected back into space. Yet these radiowaves carry very valuable information about the remote regions of the Universe.

To record these radiowaves, it is necessary to go beyond the Earth's ionosphere. Radio receivers which record radiowaves with wavelengths of 200-400 meters which arrive from out of the cosmos were installed on the Electrons. Undoubtedly, these radiowaves will bring extremely valuable scientific information about cosmic space to us.

* * *

More than a month has passed since the successful launch of Electrons 1 and 2. At 12:00 o'clock, 12 March 1964, Electron 1 had completed 357 orbits of the Earth and 155 radio sessions had been held with it.

Electron 2 had completed more than 44 orbits and 25 communications sessions had been held with it.

During the month of flight of the Electrons, great experimental material relative to the period of the Quiet Sun has been received. Further measurements by Electrons 1 and 2 will aid in the study of variations in time of the character of near-Earth space under various conditions of solar activity.

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(UNCLASSIFIED)

Scientists' Claim to Knowledgeability of Liquid Hydrogen Fueling of Rockets Discounted

An eminent Soviet physical chemist, N. M. Emanuel, who visited the US late last year, made a remark during his visit to the effect that, in the words of a listener, "because he had been instrumental in the liquid hydrogen program in the USSR, he felt he could tell us a few things about liquid-hydrogen fueling of rockets."

This is the first known Soviet claim of the use of liquid hydrogen in rocketry. When used as fuel in upper staging, liquid hydrogen can significantly increase the payload weight placed in orbit by existing boosters.

Despite Emanuel's statement, it is believed that the USSR is behind the West in the use of liquid hydrogen for this purpose, since its use in flight tests has not been detected yet in telemetry.

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'Cosmos 27' Announcement Very Likely a Cover-Up for a Venus Probe Failure

The Soviets announced on 27 March that they had launched another Earth satellite; they named it Cosmos 27. The Soviets claimed that the vehicle was successfully orbited and that its telemetry and a 19.735-mc/s beacon were working normally.

The Soviet announcement is misleading and is probably intended to cover up for a failed attempt to launch a probe toward the planet Venus.

50X1 and 3, E.O.13526

This launch is assessed as a probable Venus probe attempt, since the time and date of launch were close to optimum for a minimum-energy launch to Venus.

Moreover, the orbit of Cosmos 27 was relatively low and very circular, that is, it had the characteristics of a parking orbit. All Soviet interplanetary probes launched to date have, so far as is known, used the parking-orbit technique. Orbital parameters as announced by TASS and as developed by SPADATS are compared below:

	TASS	SPADATS
Inclination to the Equator	64.8 degrees	64.75 degrees
Orbital Period	88.7 minutes	88.28 minutes
Apogee	237 kilometers	221.5 kilometers
Perigee	192 kilometers	159.1 kilometers

[redacted] 50X1 and 3, E.O.13526

These intercepts are compatible with previous Soviet interplanetary and lunar attempts. No signals were intercepted after 0502Z, 27 March -- less than 100 minutes after launch -- contrary to the Soviet announcement that the vehicle and telemetry were functioning normally.

Cosmos 27 was initially detected by Shemya radar at 0342:34Z. The attempt to inject the payload into a transfer trajectory occurred shortly after the end of the initial orbit, that is, shortly before 0500Z, probably over the vicinity of 40° N.-35° E. The [redacted] 50X1, E.O.13526 between 0454:24Z and 0459:40Z detected as many as 16 objects in orbit, a fact indicative of a breakup of the vehicle. Moorestown, New Jersey, radar and SPASUR detected five objects in orbit as of Revolution No. 6.

If this event was a Venus probe attempt, and if the attempt had been successful, the probe would have reached Venus in about 115 days -- about 20 July.

The Soviets, by announcing the launch of "Cosmos 27," have satisfied the requirements of a UN resolution on reporting satellite launches, without, at the same time, admitting to a failure. Adlai Stevenson, US Ambassador to the UN, on 6 June charged the Soviets with failure to abide by UN General Assembly Resolution 1721 (XVI), which calls upon nations which launch objects into orbit or beyond to file reports on them promptly through the UN for purposes of registration. Stevenson named six specific instances in which the Soviets had failed to register orbital vehicles. As with "Cosmos 27," all six had been placed in parking orbit with a view to injecting payloads into transfer trajectory toward the planets or the Moon, and all had failed.

This is the second time that the Soviets have applied a Cosmos-series designation to a vehicle which could not have belonged to either of the two established types of Cosmos vehicles. Cosmos 21, launched on 11 November 1963, was the other case in which the Soviets used a Cosmos designation, to conceal either a failure or the true purpose of a launch. (See WIR 12/64.) (~~SECRET~~ NO FOREIGN DISSEMINATION Except US, UK & Canada)

technical intelligence NOTES

items of interest on technical developments around the world

Soviets Lead in Photoelectronic Image-Forming Devices Particularly in Near-Infrared Region

The Soviets appear to be well ahead of the West in the field of photoelectronic image-forming devices. Their leadership is attributable in great part to their development of materials which are photosensitive in the infrared (IR) region of the spectrum and development of techniques for producing image-forming devices.

The more common thermal -- IR -- imaging devices are quite slow, usually taking minutes to form an image. But photoelectric devices can respond in a small fraction of a second, hence they can form continuous images of rapidly moving objects. Thus they have a high potential for use in military detection systems, both active and passive. The application most highly emphasized at present by the Soviets is night operation of ground forces. This includes locating enemy armor, fire control, and operation of mobile equipment. (They might also find application in passive surveillance and in reconnaissance -- on the ground, from the air, and even from Earth satellites.)

Soviet research and development have involved several potential IR-imaging devices. The most advanced one is the IR vidicon, a photoconductive TV-type tube. Others include image intensifiers (such as the image orthicon, which presently is sensitive only in the very-near IR region) and solid-state image converters, including those with ferro-electric, or so-called electret, layers. Soviet work in extending the sensitivity of electrophotography into the near-IR appears to be well advanced over Western developments and could provide still another photoelectric near-IR imaging system.

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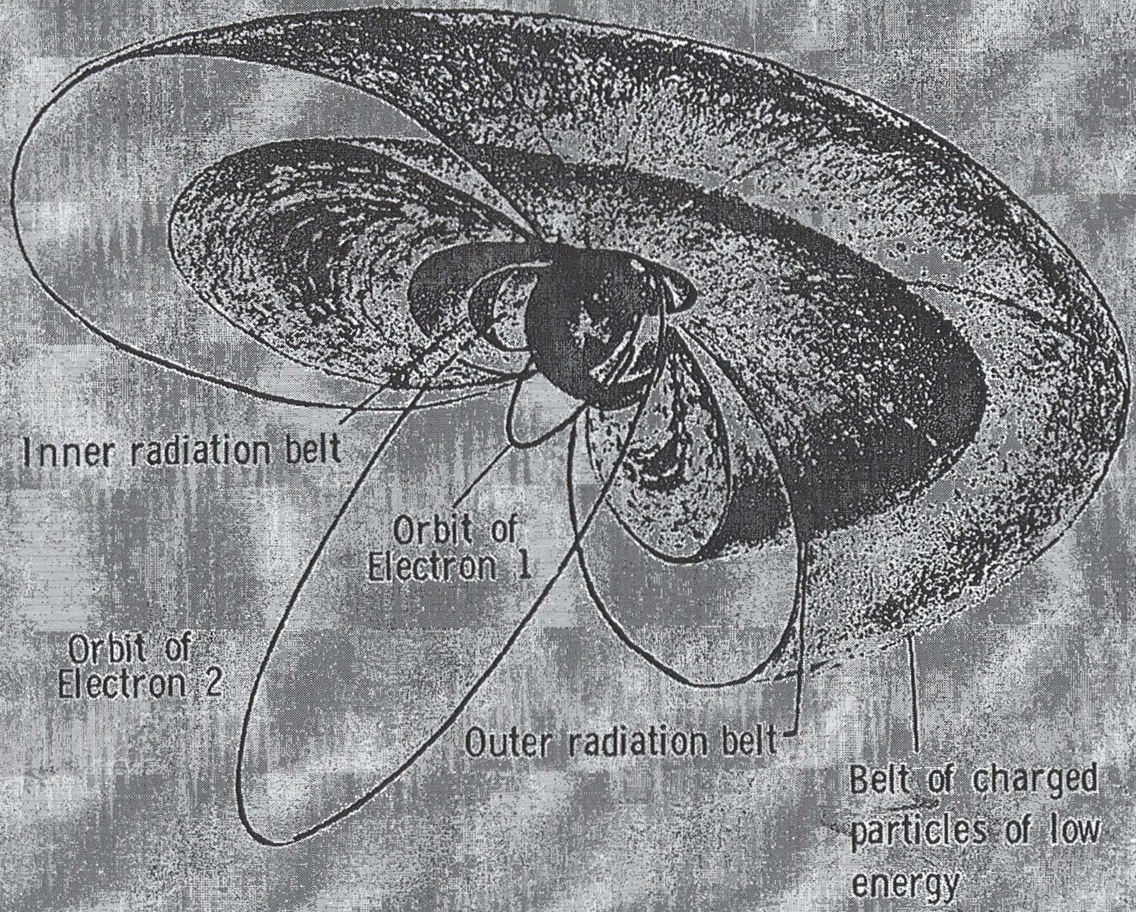
Electron 1 & 2 Orbits and the Earth's Radiation Belts (from Pravda)



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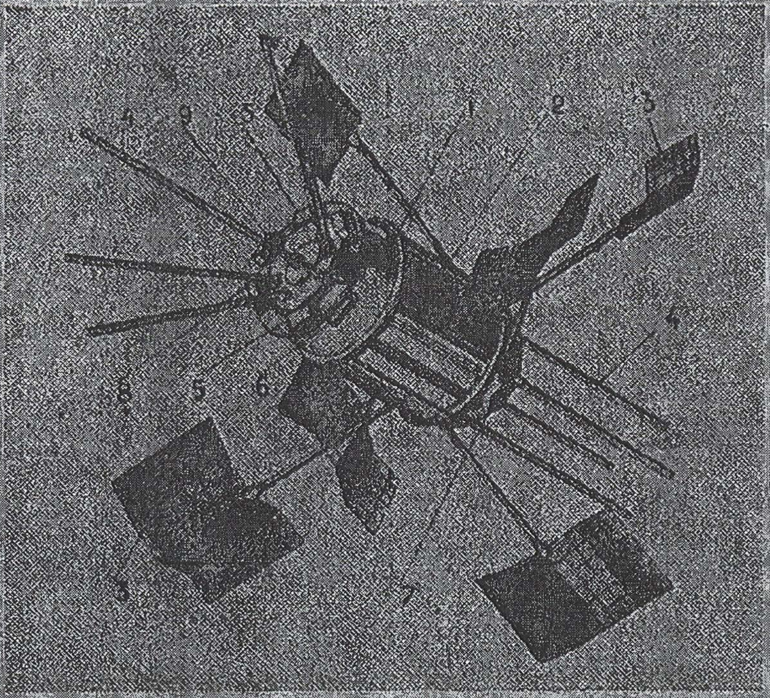
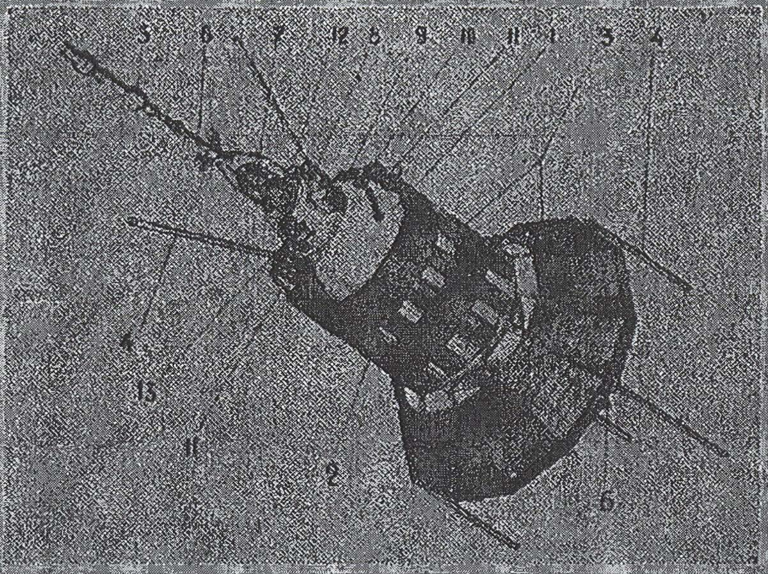
Electron 1 Space Station (from Pravda)



1. Hermetic body of the station; 2. Venetian-blind system of heat regulation; 3. Solar batteries; 4. Antennas; 5. Micrometeorite detector; 6. Device for registering corpuscular radiation; 7. Mass spectrometer; 8. Proton detector; 9. Device for study of the energy spectrum of electrons of the radiation belts.

Electron 2 Space Station (from Pravda)



1. Hermetic body of the station; 2. Venetian-blind system of heat regulation; 3. Solar batteries; 4. Antennas; 5. Magnetometer; 6. Solar-orientation sensors; 7. Spherical analyzer for study of the energy spectrum of low-energy particles; 8. Device for study of the chemical composition of cosmic rays; 9. Device for study of the energy spectrum of electrons of the radiation belts; 10. Mass spectrometer; 11. Device for research of roentgen rays of the Sun; 12. Detector of protons of low energy; 13. Charged particle trap.

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